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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 15 July 2002 with an application for Letters Patent number 520132 made by Deep Video Imaging Ltd.

Dated 23 July 2003.

PRIORITY DOCUMENT
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Commissioner of Patents

520132

PATENTS FORM NO. 4

Appln Fee: $50.00

PATENTS ACT 1953

PROVISIONAL SPECIFICATION

IMPROVED MULTILAYER VIDEO SCREEN

We, Deep Video Imaging Ltd., a New Zealand Company, of Hamilton, New Zealand, do hereby declare this invention to be described in the following statement:

PROVISIONAL SPECIFICATION

IMPROVED MULTILAYER VIDEO SCREEN

Technical Field

This invention relates to methods of providing improved quality video display system

Background Art

A method of creating the appearance of depth in video displays is to use a multilayer display system typically comprising at least two parallel coaxial video screens separated by between 10 and 100 millimetres in depth. The rear screen can be larger than the front screen and the screens are preferably separated by a slab of clear material of refractive index substantially greater than 1 which both supports the two screens and helps avoid the effect of looking through a window in that the edges of the view between the screens are made to largely disappear. The front screen is transparent except where its pixels are activated to create a display so that it is possible to see behind much of the front screen to the background shown on the rear screen. Backlighting for the front screen is provided by illumination from the rear screen or more commonly a common backlight is used for both screens, being placed behind the rear screen which for this case is also transparent except where pixels are activated. The front screen can also be formed from transparent electro-luminescent technology where pixels and sub-pixels produce their own light. With the backlit system it is found that there is sufficient diffusion of light from the back screen even when activated to allow normal colour vision on the front screen as well.

It is known from studies of human vision that the human eye is more sensitive to intensity than colour in interpreting detail in images. Furthermore, of the primary colours red green and blue, the eye is least sensitive to blue. The relative sensitivity of the eye to red is 0.51 compared to green and to blue is 0.19. Accordingly a video image in which the blue sub-pixels are up to 5 times the area of the green sub-pixels shows no

obvious visual loss of resolution compared to an image in which the blue sub-pixels are the same size as the green sub-pixels. Therefore it is possible to reduce the cost of a video pixel system by using a smaller number of larger blue sub-pixels without losing resolution.

The basic form of the multilayer display as described above suffers from certain problems. When similar liquid crystal display screens are used for both the front and rear screens the display suffers from a Moiré fringe pattern which makes it unusable. Moiré interference is usually described as "an independent usually shimmering pattern seen when two geometrically regular patterns (such as two sets of parallel lines or two liquid crystal display screens) are superimposed especially at an acute angle". The independent pattern seen is the result of the interference between the two or more regular patterns. This is normally circumvented by placing a diffusing layer immediately in front of the rear (most) screen(s). However one effect of the diffusion screen is to reduce the sharpness of the rear screen to viewers. Another undesirable effect is to reduce the contrast of the rear screen to viewers.

A further problem with the system is that it is difficult to get sufficient brightness from the backlighting for the display. By improving the transparency of one or more of the pixel patterns the brightness of the image seen in the display can be improved.

The contrast sensitivity of the human visual system is the capability of the latter to detect the difference in brightness between neighboring regions in a scene. A high sensitivity means the ability to distinguish small differences in brightness. Human visual contrast sensitivity is largely dependent upon the sizes of the neighboring regions in question. That is, the sensitivity is a function of spatial frequency. Many psychophysical experiments have been conducted to determine how the human visual contrast sensitivity varies with spatial frequency. Most often used as test

scenes are bar patterns or gratings with different spatial frequencies and contrast. For each frequency, gratings of different contrast are shown to human subjects to determine the lowest contrast discernible. It turns out that the human visual contrast sensitivity also varies with the orientation of the grating; it achieves the highest value when a grating is horizontally or vertically oriented and achieves the lowest value when a grating is oriented at 45 degrees from horizontal. Different results are obtained by different experimenters due in part to different experimental conditions and assumptions. However, all the results show that the human visual contrast sensitivity, as a function of spatial frequency, varies in a curve. The curve has the normalized sensitivity and is based on the data obtained by several experimenters. In most experimental results the spatial frequency is expressed in terms of cycles per degree of a subject's field of view. This unit is translated to cycles per inch (cpi) at a normal viewing distance of 12 inches. The peaks of the curves from different experimenters range from about 10 cycles per inch to 50 cycles per inch with an average of about 20 cycles per inch. The sensitivity drops rapidly at frequencies away from the peak frequency.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided a method of making a multilayer display system wherein

a) Image formation layers are chosen so as to render the moiré

interference produced substantially indistinguishable to the human visual system.

b) Different pixel patterns may be chosen on the front and rear image formation layers to prevent the formation of Moiré fringe patterns substantially distinguishable to the human visual system.

c) Different sub-pixel patterns may be used on the front and rear image formation layers to prevent the formation of Moiré fringe patterns substantially distinguishable to the human visual system.

d) Sub-pixel patterns may be contained within a tessellated geometric pattern where the edges of the sub pixels may be curved and the shape of the sub-pixels may be chosen to avoid moiré interference.

e) On one or all image formation layers for each sub-pixel may typically surrounded by sub-pixels of a different colour

f) Sub-pixels and pixels may be arranged on one or both screens in a tessellated pattern to simplify manufacture and to optimise the connections to the rows and columns.

g) The slope of the borders of the pixels formed on a previous screen may be at an angle between 1 degree and 90 degrees to those of a subsequent screen

h) The slope of the borders of the sub-pixels formed on a previous screen may be at an angle between 1 degree and 90 degrees to those of a subsequent screen

i) Interstitial layers are placed between the image formation layers so as to prevent the formation of moiré interference whilst not producing changes in the sharpness, brightness and chromatic features of the image formation layers, which are substantially distinguishable by the human visual system.

j) Said interstitial layers may be recorded using holographic techniques, and may be produced and placed at a distance from image layers so as to render the moiré interference indistinguishable to the human visual system.

k) Said interstitial layers may be reproduced using micro replication techniques, involving embossing, calendaring, etching, scratching, scouring, or moulding.

l) Said interstitial layers may be reproduced directly on image formation layers or on separate films between image formation layers.

m) Said interstitial layers may be placed a particular distance from the image so as to control blur of image formation layers.

n) Said interstitial layers may take rays entering from a single direction randomly distributing the direction of the rays within a predetermined cone.

Reference throughout this specification will now be made to the present invention as applying to video screens for a multilayer display system. However, it should be appreciated by those skilled in the art that other types of displays using one or more screens may be used in conjunction with the invention, not necessarily being for a multilayer display system.

In theory, moiré interference in layered displays appears when geometrical patterns with a similar spatial frequency are overlaid. The resulting interference occurs as a variation in density of the interfering elements and has a much larger period than the contributing patterns. In multi-layered displays this description can divide further by considering three separate geometric patterns which can be, depending on the technology employed

a) the black pixel matrix

b) the column and row lines and other opaque driving electronics

c) colour filters

The interference between subsequent black pixel matrices appears as a periodic variation in the density of the black lines in both the horizontal and vertical directions. And while individual lines may be too small to be detected when each pattern is viewed separately, the periodic variation in density may be detectable and is often annoying to the viewer. The same can be said for the driving electronic matrix.

The interference between subsequent colour filter elements appears as sets of large fringes, each set composed of distinct colours similar to those in the contributing pattern. Individual fringes appear when colour filters of the same type appear overlapping or partially overlapping to the viewer. The perceived colour of the fringes is less saturated than that of the contributing filters because overlapping of dissimilar colour filters does not produce black.

In order to achieve minimal moiré interference perception the contrast and spatial frequency of the moiré fringes produced needs to be below the threshold of the human visual system. Since the frequency of the moiré interference varies depending on the viewing distance and the distance between the layers and it is preferable that these parameters free for other purposes, counter measures need to be directed towards lessening the contrast of the interference.

To achieve minimal contrast in the resulting fringes by the layers the shape of the colour sub-pixels on separate layers has to be chosen carefully, so that when the patterns are overlaid there is minimal variation in the area of intersection of the colour stripes as one moves along the horizontal or vertical axis of the display. The patterns may be formed by dividing the simple geometric shapes forming the tessellation

into different sub-pixel regions with straight or curved borders.

Whilst using dissimilar pixel and sub-pixel arrangements may be a useful counter measure to moiré interference additional, although minimal blurring of the sub-pixels may still be necessary to reduce the contrast of the moiré fringes and hence make them imperceptible to human visual system, this is best achieved with a directional diffuser. The simplest form of which is made by interfering a plane or diverging wave with a diffuse wave in either a reflection or transmission format. The resulting hologram will reconstruct the diffuse source when illuminated at the original angle. The position and size of the original diffuse source will determine the projection zone and the gain of the screen. A small diffuse source recorded a meter away from the holographic plate will form a very high gain screen that is visible only when the viewer is in the angular zone subtended by the small source at 1 meter.

The directional diffuser effectively blurs the image by taking light emitted by the image and randomly changes its direction by an angle somewhere between zero and the projection angle. Since the directional diffuser is placed at a particular distance from the image formation layer light appears to have come from a point a small distance from its actual origin. By changing both projection angle and the distance from the image formation layer, both the gain of the display and image blur size can be controlled. The image should be spread as uniformly as possible over a distance of at least one pixel, thus decreasing the contrast of the small features that contribute to the moiré interference and hence the viewers perception of it. It is preferable to spread the image of the sub-pixel no more than one pixel since this can over blur the image, decreasing its visibility. Since most existing technology is optimised to be viewable from all angles it is desirable to make the projection angle as small as practically possible and have the holographic diffuser at a large distance from the image formation layer, so as not to loose contrast of the overall display.

Whilst the holographic diffusion pattern may be recorded using a laser and mask arrangement it can be reproduced, and indeed any diffusion pattern may be produced to within a given tolerance by many different methods. One such method is calenderending where an adhesive, usually epoxy that is curable by ultra-violet radiation, is applied to the desired surface and a 3D negative impression of the surface, on a transparent substrate, to be reproduced is pushed into the adhesive. The adhesive is then cured by applying the UV radiation through the substrate, and the substrate removed leaving a surface impression. Also the pattern may be applied to the surface during its manufacturing process, such as embossing the pattern onto a plastic sheet whilst the surface is still soft. It also may be applied using material removal systems such as acid or abrasion.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 Is a diagrammatic view of a pixel where the sub pixels are in the vertical stripe arrangement. (1) corresponds to a red sub pixel, (2) corresponds to a green sub pixel, (3) corresponds to a blue sub pixel

Figure 2 is a diagrammatic view of a moiré interference pattern in where the black lines represent one colour from a stripe pattern pixel. The vertical section delimited by braces (4) shows where the moiré pattern is most dense and the vertical section delimited by braces (5) shows where the interference is least dense.

Figure 3 is an oblique view of a multi layer display showing backlight (6), two image formation layers (7) and (9) and interstitial films (8)

Figure 4 is a profile view of a multi layer display showing backlight (10), two image formation layers (11) and (13) and interstitial films (12)

Figure 5 is an example of a sub pixel of an alternative arrangement where a centre blue diamond (14) with straight edges is placed within a square (15) and surrounded by red (15) and green (16) sub pixels which occupy the remaining area within

Figure 6 shows the moiré interference produced by the centre blue region of the alternative arrangement in figure 6, where there is less difference when compared to figure 2 in density between the less dense vertical region delimited by braces (17) and the more dense strip delimited by braces (18)

Figure 7 shows a further alternative sub pixel arrangement where a centre blue sub pixel (17) with arc shaped edges is adjacent to a red sub pixel (18) and a green sub pixel (19)

Figure 8 shows the moiré interference produced by the centre blue region of the alternative arrangement in figure 8, where there is less difference when compared to figure 2 in density between the less dense vertical region delimited by braces (20) and the more dense vertical region delimited by braces (21)

Figure 9 shows the output cone (20) of directional diffuser (21) on light rays (22) emitted from image formation layers

Figure 10 shows ideal intensity profile (25) of a rectangular sub pixel after being blurred by diffuser, compared with the intensity

distribution of sub-pixel (24) before being diffused by diffuser where (25) denotes x-axis and (23) denotes the horizontal axis of the image formation layer.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 3 illustrates multi-layered display composed of a backlight (6) behind and co-linear with rear image plane (9) with a modified pixel pattern (5), a directional diffuser (8) and a front image plane (9) with standard pixel pattern Figure 1.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

Signed

Gareth Bell

for Deep Video Imaging Ltd.

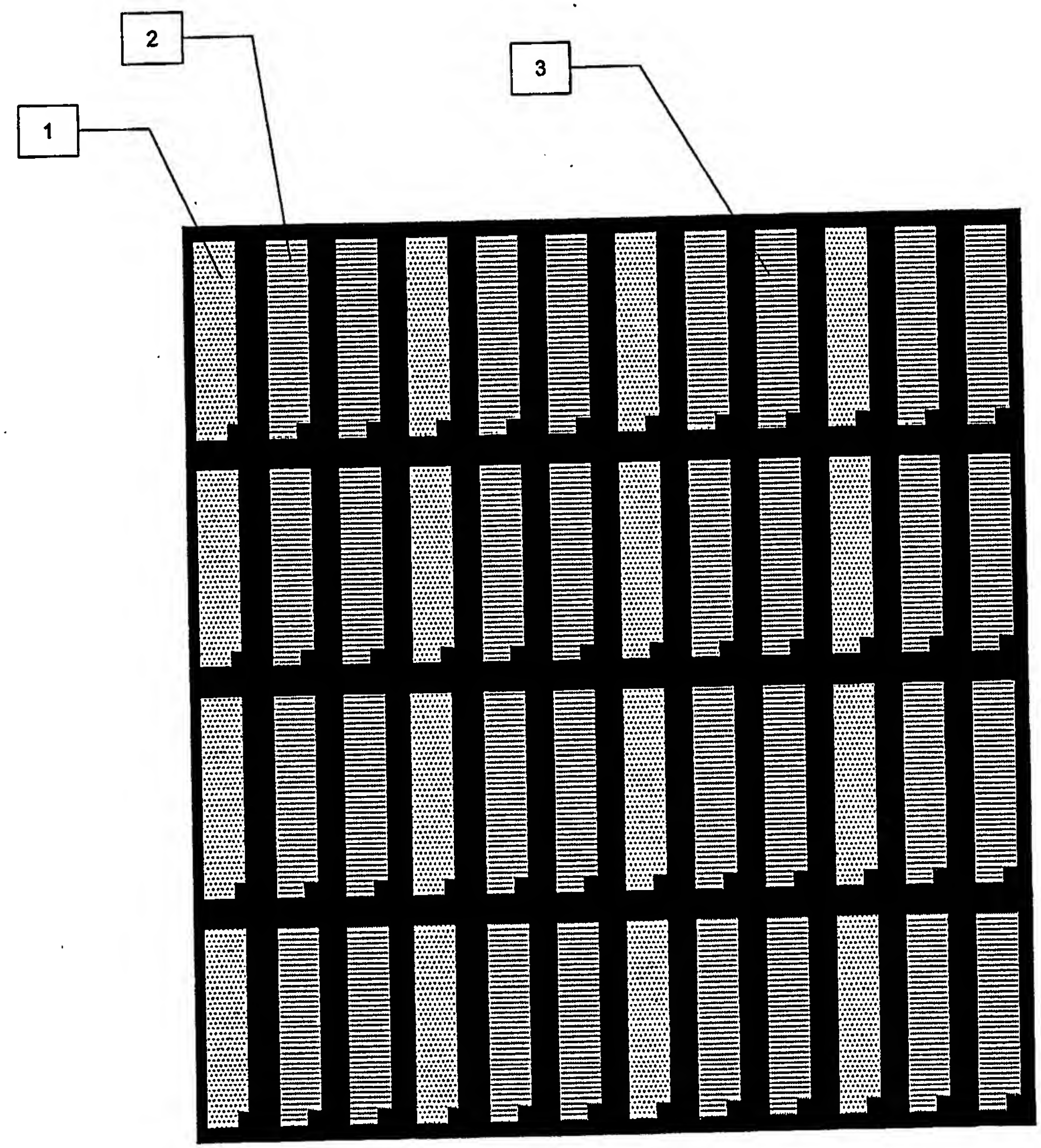

Figure 1

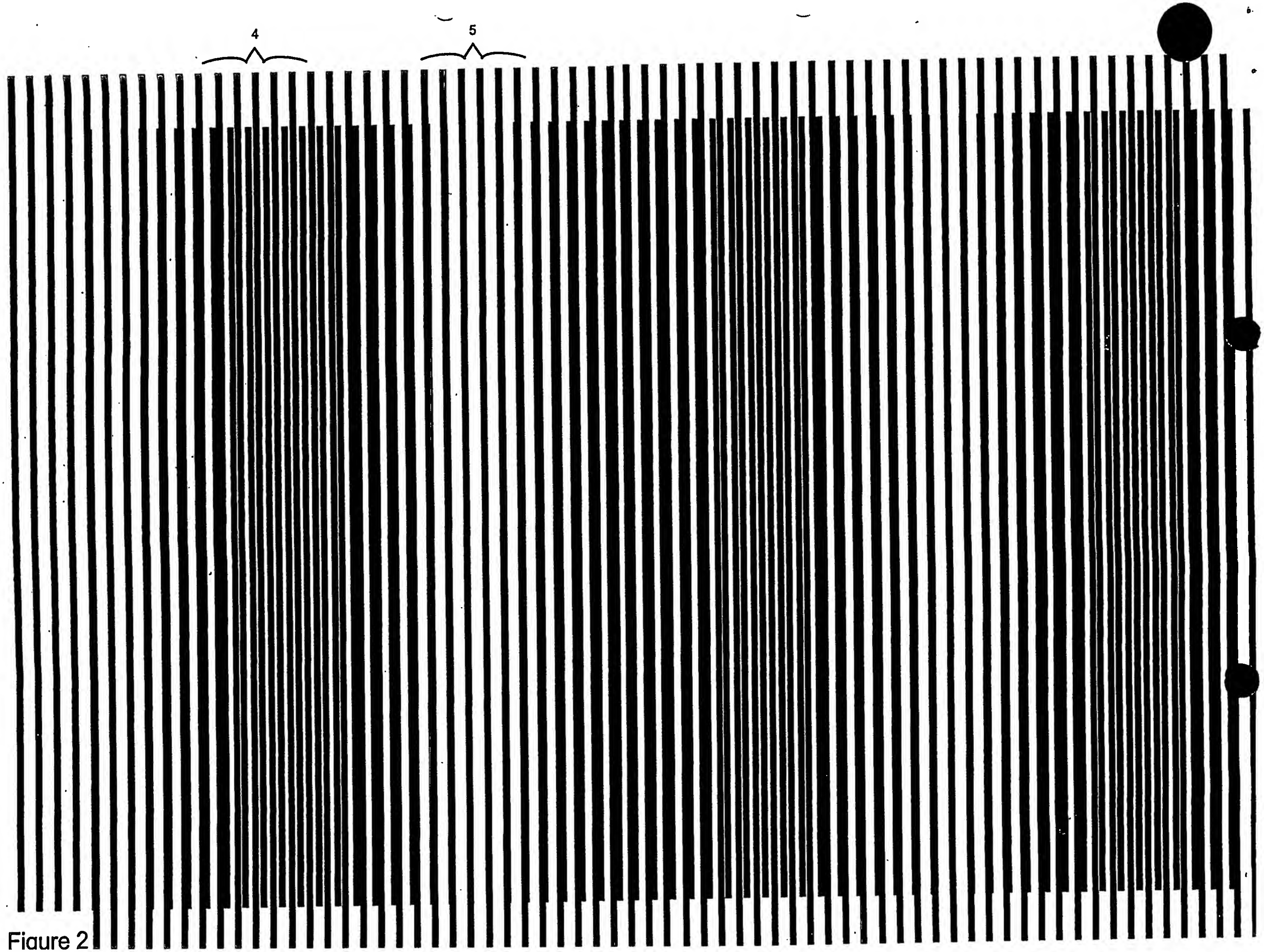

Figure 2

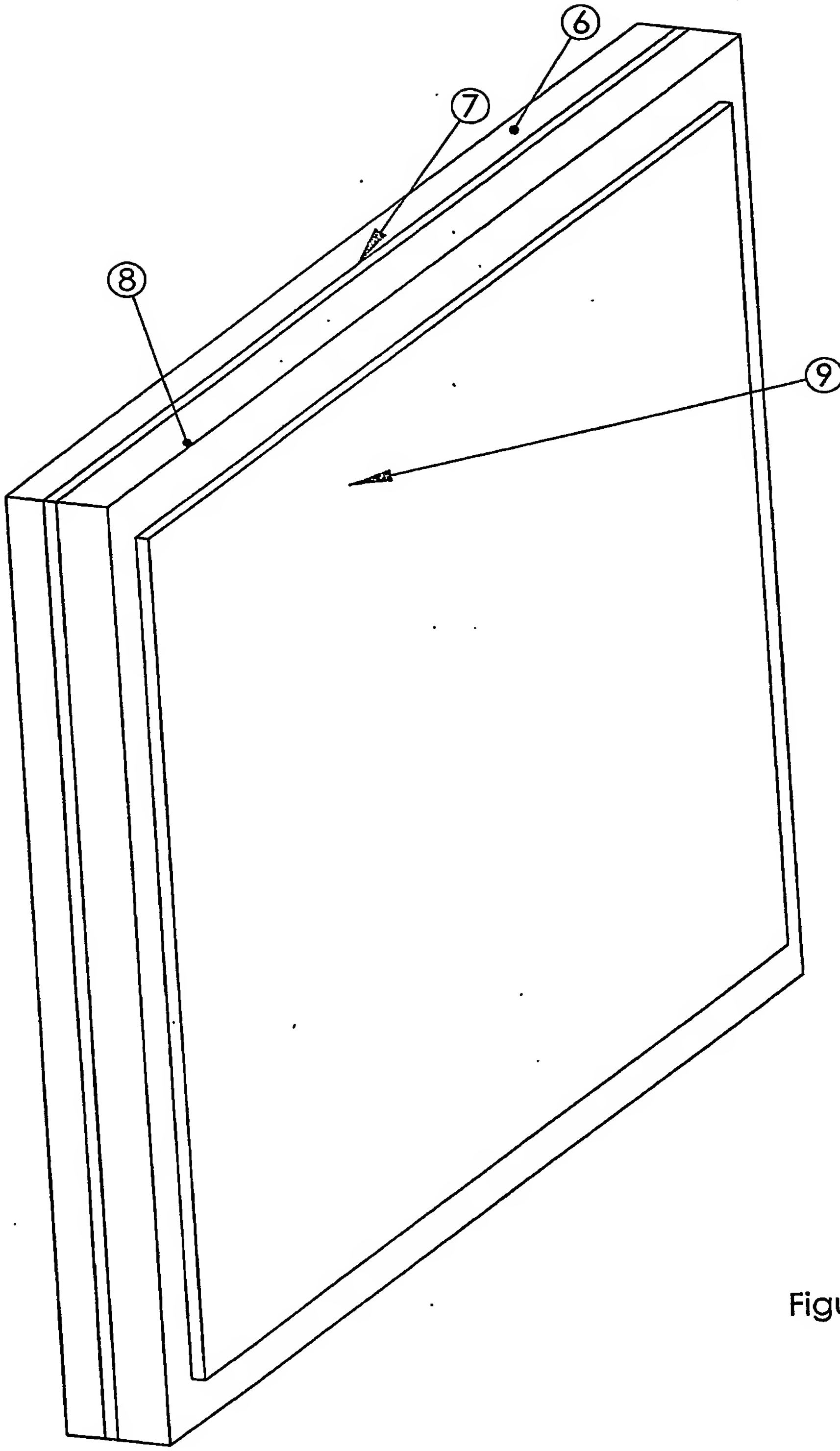

Figure 3

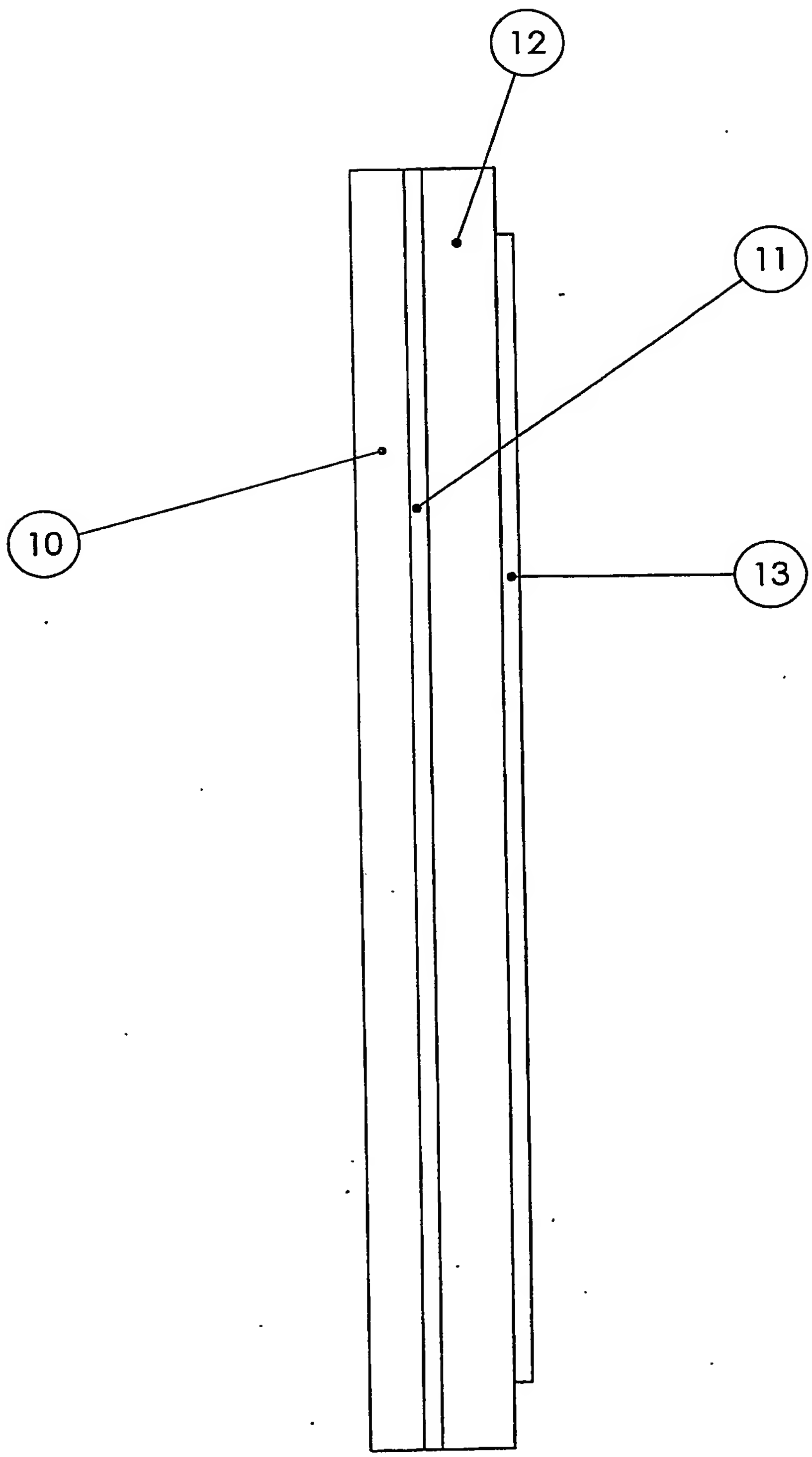

Figure 4

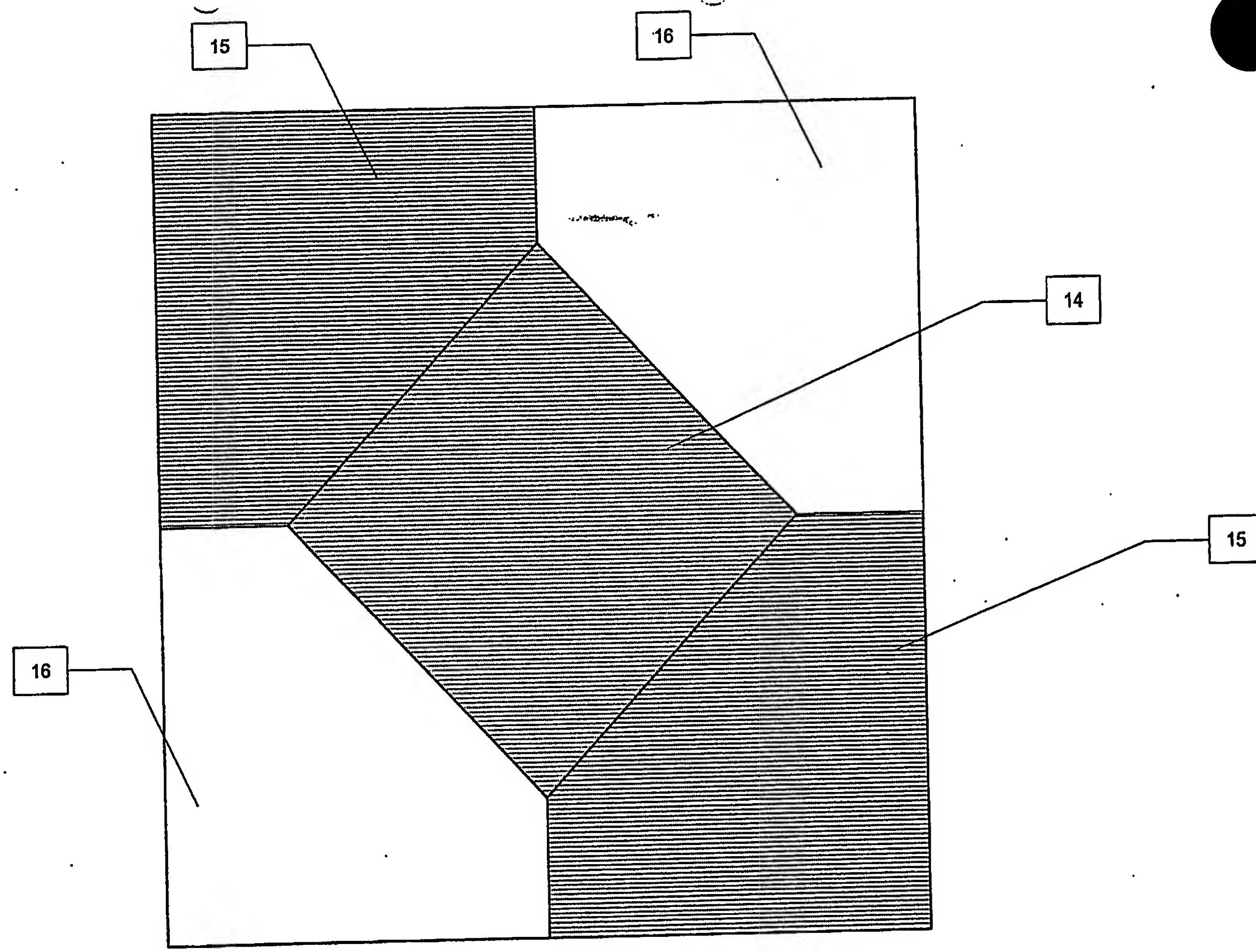

Figure 5

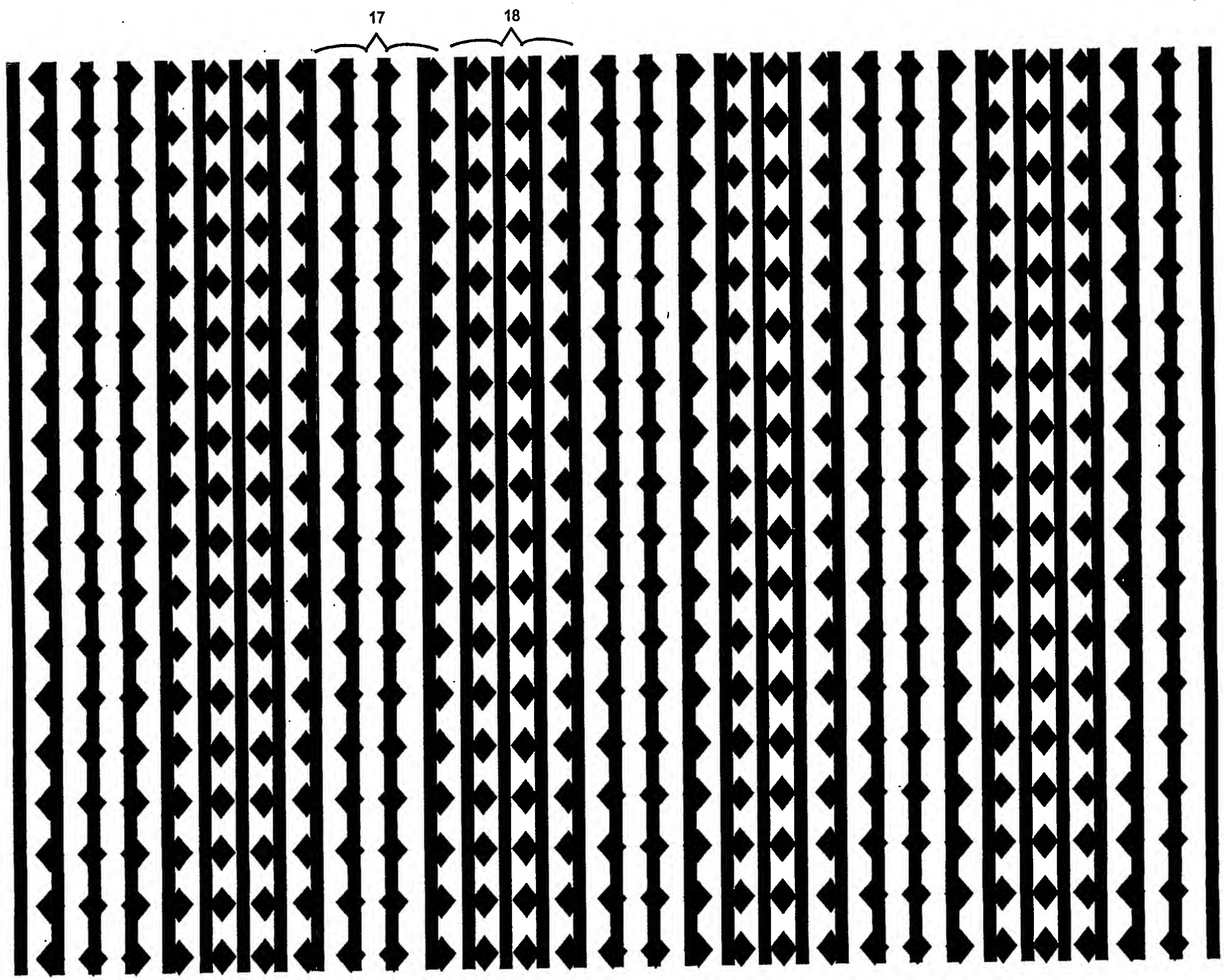

Figure 6

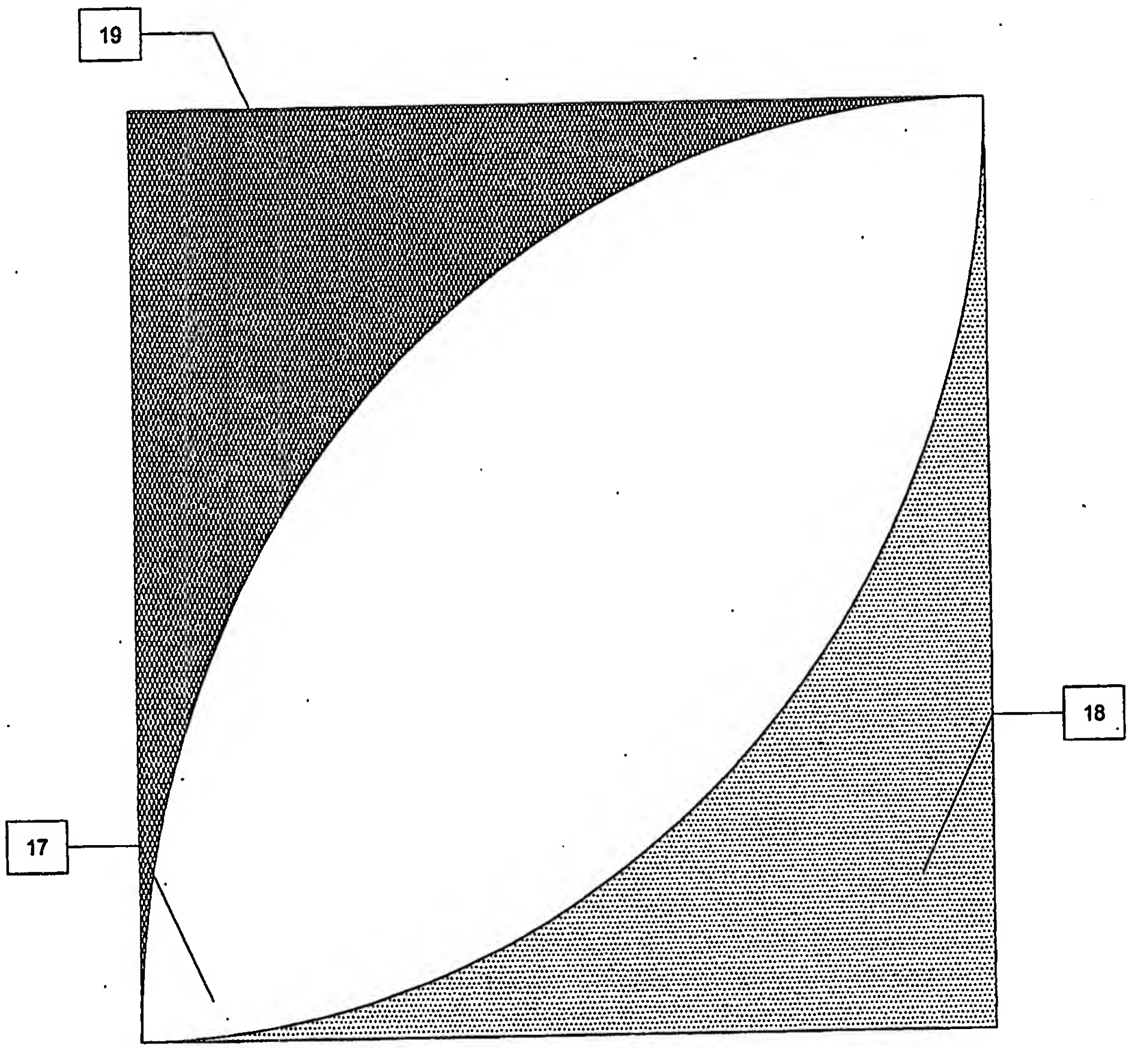

Figure 7

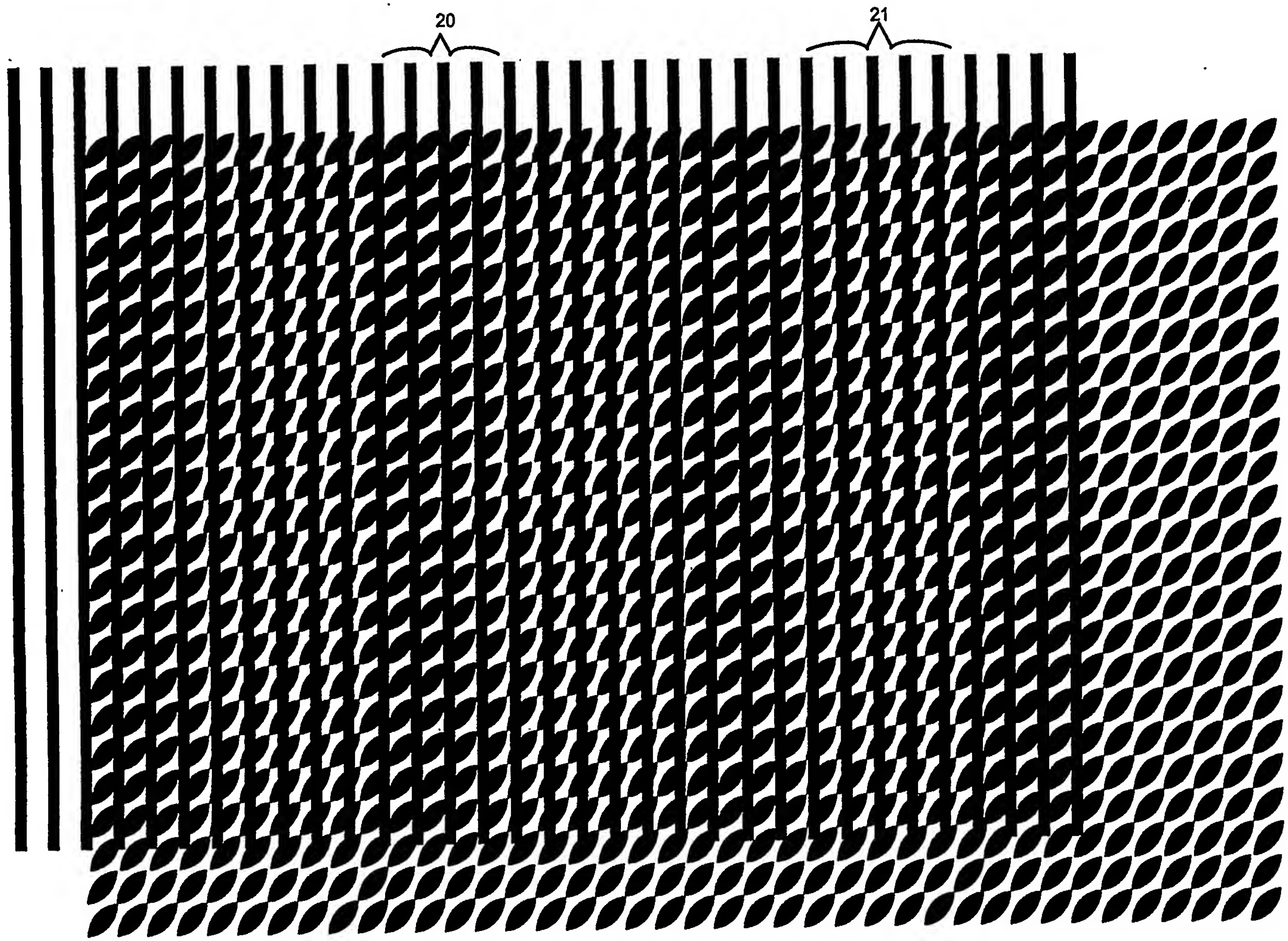

Figure 8

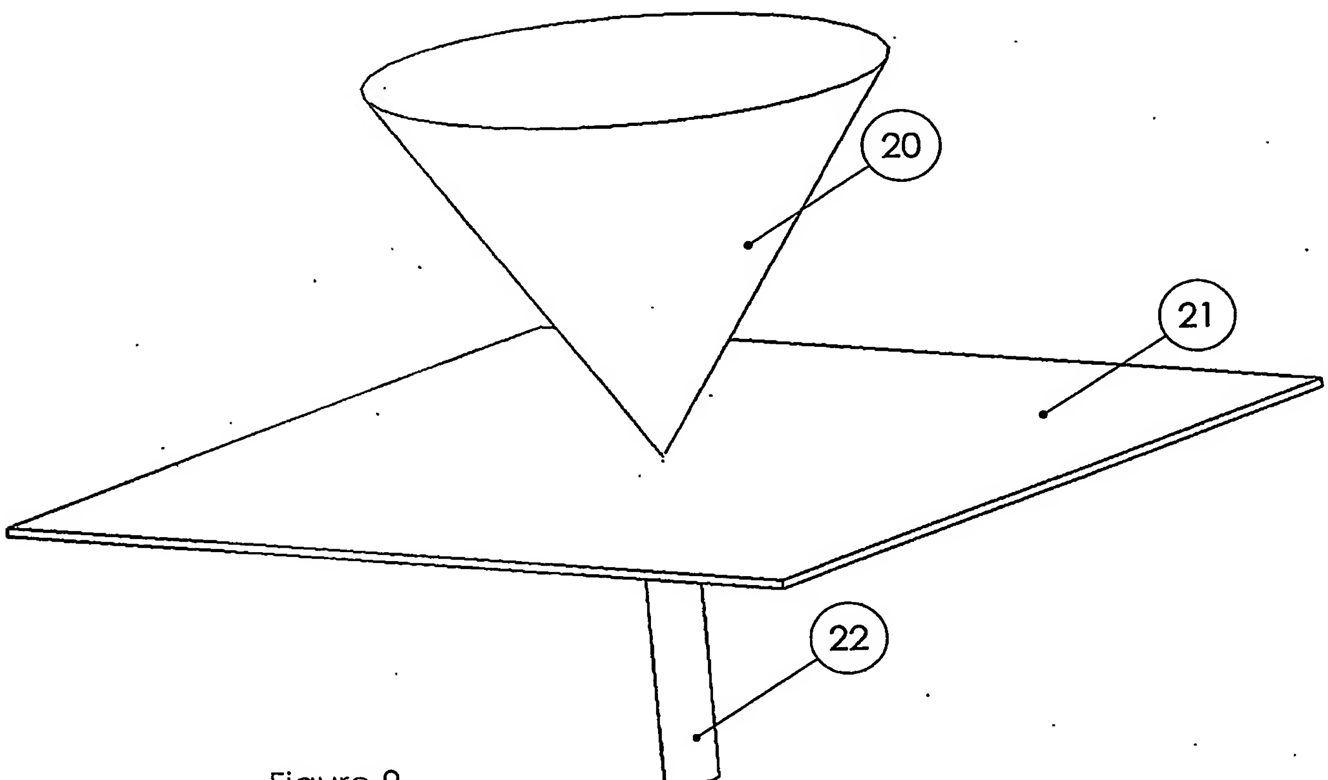

Figure 9

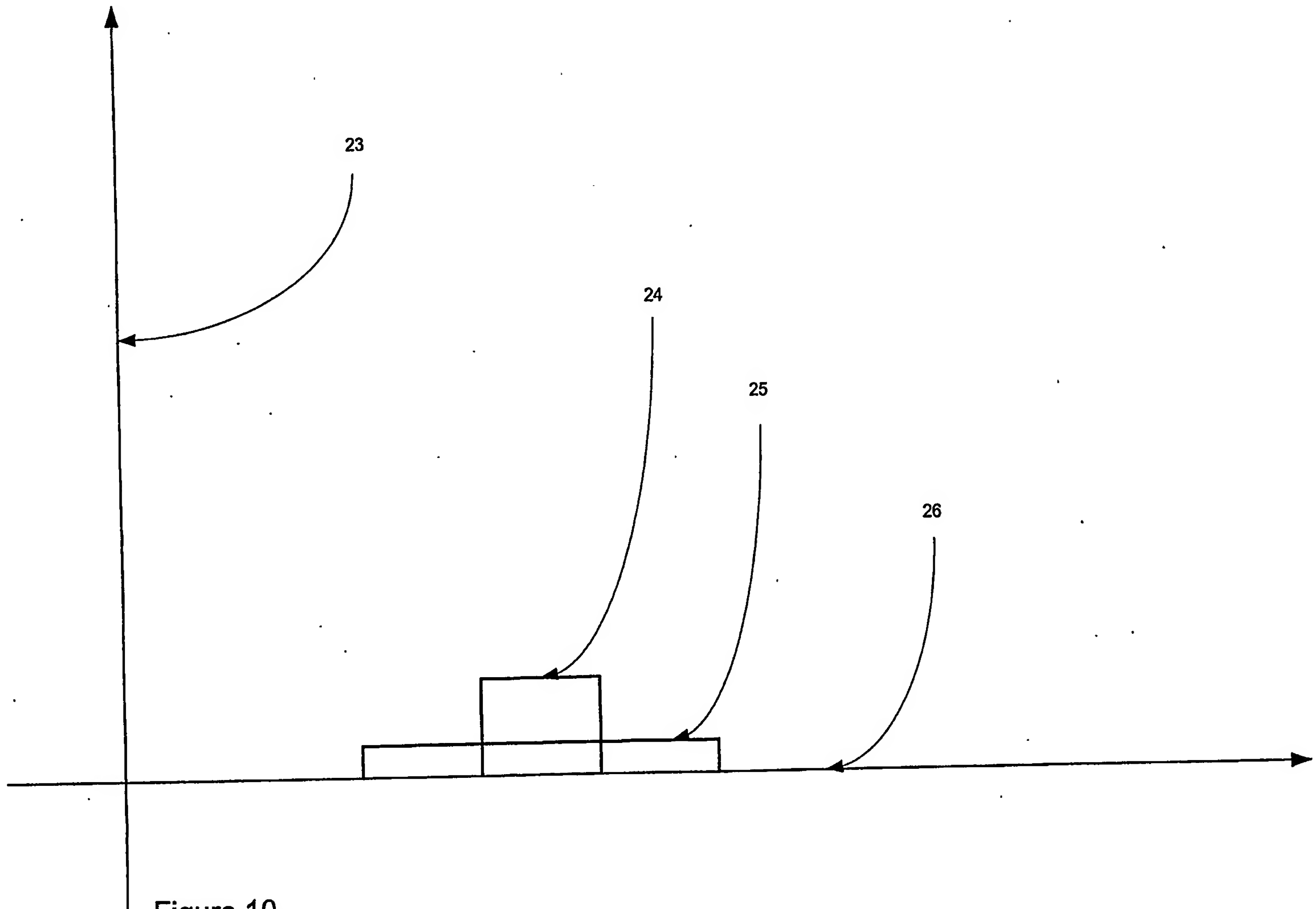

Figure 10